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学 位 論 文 内 容 の 要 旨
DISSERTATION ABSTRACT

博士の専攻分野の名称　　博士（工学）　　氏名　Saran Keeratihattayakorn

学 位 論 文 題 名
Title of dissertation submitted for the degree

Muscle Activating Force Detection Using Surface Electromyography
(表面筋電位を用いた筋活動力検出に関する研究)

Human body movement is generated by muscle force. Daily activities such as grasping an object, using a hand tool and walking require cooperative of muscles in upper and lower extremities. In order to understand muscle function and mechanics, measuring of muscle force during contraction is necessary. Direct measurement of muscle force is impractical and invasive. Electromyography (EMG) is a bioelectrical signal that usually used to observe muscle activity during contraction. Surface electrode can be attached to skin and used to detect surface EMG signal. The aim of this study is to develop methods to estimate muscle force using surface EMG signal. An EMG-driven method for estimating muscle force during elbow and knee flexion/extension movement was proposed. Surface EMG signals detected from muscles and kinetic data were measured and used as input in the EMG-driven model. The effect of dynamic movement on surface EMG signal was studied. EMG-driven model can be used to estimate muscle force during elbow and knee joint movement. However, measuring muscle activity within the forearm region is difficult due to complexity of muscles that reside within the forearm. The individual activity of deep muscle cannot be observed by conventional surface electrode. A novel method called Electromyography Computed Tomography (EMG-CT) method was proposed for measuring the individual muscle activities in the human forearm. The muscle activities in the whole cross-section were calculated from EMG signals obtained by multiple surface electrodes attached around the forearm. The individual muscle activities in the deep region were estimated and used to produce an EMG tomographic image. The muscle activity distribution identified by EMG-CT has high potential to estimate muscle stress in the forearm muscles. Thus, a method to estimate muscle stress distribution from muscle activity based on EMG-CT was proposed. The muscle stress was calculated from the relationship between gripping force and total muscle activity obtained by EMG-CT. As a result, the distribution of muscle stress in the forearm during hand gripping was estimated and visualized.

Chapter 1 introduces the background relevant to this study. Aim and scope of this thesis is also presented.

Chapter 2 presents basic knowledge of muscle physiology and EMG signal. In order to understand the relationship between muscle activity and EMG, knowledge of structure and function of muscle and nature of EMG are provided.

Chapter 3 presents a method to estimate muscle force from surface EMG called EMG-driven model. EMG-driven model was implemented to estimate muscle force in elbow and knee joint during flex-

ion/extension movement. Surface EMG signal detected from the muscles and kinematic data were measured and used as inputs in biomechanical model. The optimization process was used to obtain muscle model parameter by minimizing the different between the estimated and the experimental results. Individual muscle forces in upper and lower extremity were estimated during various movement speeds. The study also showed the effect of dynamic movement on EMG signals.

Chapter 4 presents a method called Electromyography Computed Tomography (EMG-CT) which was developed to measure individual muscle activity within the deep region of human forearm using multi surface electrode. EMG conduction model was formulated to reverse calculation of surface EMG from the muscle activation. The individual muscle activities in the deep region were estimated and used to produce an EMG tomographic image. For validation of the model, isometric contraction of finger muscle was examined. It is demonstrated that EMG-CT was able to estimate individual muscle activation in a non-invasive manner.

Chapter 5 presents a novel method to estimate muscle stress, i.e. force generated during contraction per unit area in the whole cross-section of the forearm based on EMG-CT. Muscle activities within the forearm during hand gripping were measure using EMG-CT. An EMG conduction model of the forearm was constructed using outline geometry of the subject's forearm which was measured with a handy 3D scanner. The stress of muscle was calculated from the relationship between gripping force and total muscle activity. As a result, the distribution of muscle stress in the forearm during hand gripping was visualized in a tomographic image.

Chapter 6 concludes the work in this thesis and future works are discussed.

The developed methods for estimating muscle force from surface EMG signal in this study provide valuable tools to study muscle function and its mechanism. Muscle force in elbow and knee joint can be estimated by EMG-driven model. The EMG-CT method was proposed to measure muscle activity within the forearm. The developed muscle stress estimation method using EMG-CT provide a tool for clinical application such as determining the effectiveness of surgical or rehabilitation procedures. The developed method also opens a new window of studying muscle and capability that may advance the development of diagnostic tools.